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MINERALS SCENARIOS

Developed By

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Locatable Minerals

Locatable minerals activity in the California desert would include numerous small lode operations (subsurface, on veins) for gold and other metallics; perhaps some larger subsurface operaions for disseminated metallics and industrial minerals; numerous small to moderately large (to 50 acres) open pit operations for industrial minerals and metallics; a few large, open pit operations on the order of 500 acres or more; numerous, small placer gold operations. Operational lives can vary from a few months, intermittently, for small placer and lode operations to 5 to 30 years or more. Different mineral occurrences may require particular methods of detection and exploitation. With all these variables there are still some common environmental effects from activities during the progressive stages of mining.

Lode Mining

Sequential operations

Exploration

Initial on-the-ground exploration techniques include geologic surveys (examination of outcrops) and many optional geophysical and geochemical surveys, most involving light vehicle access or foot traverses using portable equipment. The activity covers broad areas with use intensity and effects comparable to recreational touring and hiking.

If anomalies or mineral showings are found, exploration proceeds with increasing intensity involving three dimensional physical access: for a vein deposit this might involve surface cuts, then short adits and/or

shafts in conjuction with a few drill holes. For large, low grade metallic or industrial minerals the work might consist of trenching and successive drilling patterns aiming to identify and outline the deposit. Exploration headings (adits, shafts) may be driven on drill holes or independently, to confirm drill hole sampling and to develop bulk samples for metallurgical (ore processing) testing. If or when evaluation admits economic feasibility of mining, and further work is considered development.

A series of minor surface trenches, pits and cuts can be completed within a few weeks. Adits and shafts can take up to several months to complete (perhaps 5 - 10 feet of advance per day). The areas affected are the actual surface exposures of the workings and their dumps, perhaps averaging 20 x 30 feet (0.01 acres each) and their access (about 2 acres per mile) so that surface effects would rarely exceed 5 - 10 acres within the several hundredacre target area.

Surface effects from drilling involve access for drills on medium to heavy duty trucks (about 2½ acres per mile) and drill pads of from 15 x 15 to 30 x 30 feet (0.005 to 0.02 acres each)). For example, drilling 640 acres on a 500 foot grid would involve from less than 1 to 2 acres in drill pads and about 15 - 20 acres in access. If water is used to raise, drill cuttings, alkaline mud conditioners (dispersants such as sodium tetraphosphate) may be used. Small amounts of petroleum may be used to lubricate the drill column. Drilling rates would vary from about 35 feet per day for diamond drilling in hard rock to several hundred feet per day with rotary drilling in sediments. Duration of drilling program would be from a few weeks to several months using several crews.

The activities would involve minor intermittent dust from vehicle travel and the other surface activities.

While these activities are more or less sequential, some of them may be omitted or short circuited by discovery of an ore deposit at an early stage.

Development

A drilling program would continue into development within the existing drilling grid to refine information on the deposit for design of the mining (and possibly milling) program. Drill patten and intensity would depend upon homogeneity of the ore: erratic mineralization would require closer sampling intervals. For the 640 acre example, filling in the 500 foot drilling grid to a 100 foot grid would increase access area in additional 20 acres to 30 - 40 acres, and drill pad areas to a total of 15 to 50 acres. Drilling may involve use of alkaline drilling muds and petroleum lubricant for the drill column. Duration may be from several weeks to several months.

Surface development (open pit) would involve stripping the overburden and development of initial benches or working faces. The materials may be stacked nearby or used to construct tailings ponds if milling is involved, or stacked on impervious pads for leaching of mineral values. Removal of overbruden may require up to two years for the large copper mines. Development of pit benches may take a few weeks to a year for large pits. Areas involved are the pit design limits as of the current mining plan, perhaps 20 - 50 acres to upwards of 500 acres, the same area involved in target drilling efforts. The operations would involve

moderate to high, intermittent dust from stripping and blasting.

A subsurface development in vein mining or large scale subsurface methods such as block caving involves development of subsurface access and facilities for extraction, storage and hoisting of ore and waste. Development may take less than a year to two years depending upon mine size and mining method. Surface effects would be limited to the small areas of access to subsurface workings and the initial waste dumps. Pumping and water discharge problems would be minor to nil in desert areas.

Surface facilities may consist of offices, assay or testing labs, warehouses, maintenance shops and possibly a mill. Mills are usually crushing and grinding facilities with separation or from simple washing and sorting, or gravity method such as jigs and tables, or heavy media separation, air float separation, cyanidation or flotation, or sometime several in conjunction. Surface facilities can vary from a few acres in small vein mines to 20 - 30 acres for larger mines to on the order of 100 acres for a large, open pit mine.

Surface access within the mine area would occupy fractional areas within intensive use areas. Access to the mine may require extending existing access by as much as 50 to 10 miles. Construction of paved road or rail access would take perhaps several months to a year. Utilities (water, power, gas) would likely follow the same access route during the same construction period. Access and utilities may occupy up to 5 - 6 acres per mile depending upon terrain (rough country would produce widened cut and fill areas). Water storage reservoirs may occupy an acre

to several acres near the surface facilities.

There would be intermittent, moderate generation of dust during activities of surface development and construction.

Extraction

Open pit mining involves advancing downward on a series of benches from the perimeter, steepening the average pit slope (through benches) as the final pit limit is reached. Final pit slopes may range from 25° to 50° depending upon competency of the rock. Duration of mining could be from about 5 to 30 years or more, covering the surface area previously involved in target exploration and development activities: a few acres to 50 acres to 500 acres or more for a large, open pit mine. The effects would be intensive: cycles of blasting, loading, and hauling with accompanying dust and gases.

Subsurface mining effects could be minimal, with intensife use at portal areas. Block caving effects may vary from nothing for deeper deposits, to subsidence and funneling of surface materials into the center of the area caved. This would be the area already subjected to intensive exploration and development.

Effects from milling operations may range from minor dust to residues and gases from flotation and cyanidation processes. Flotation involves the use of water and several pounds of various organic and mineral oils, mineral acids and alkalies and various flocculants such as calgon. These are consumed to some extent and are contained within ore concentrates and as residues in the tailings. Cyanidation is used to recover gold, and sometimes silver, by dissolving in a weak solution (about one pound per ton

of water) of sodium or calcium cyanide, with solutions recirculated for reuse. Tailings are given a final fresh water wash to extract greatest possible values but may still contain cyanide residue.

Mine waste may be spread over disposal areas, or used to construct tailings dams, or in the case of copper, gold and silver ores (and possibly uranium) may be leached by stacking on impervious pads (asphalt, butyl _ plastic). Leaching is accomplished by weak acids (for copper and uranium) or cyanide solutions (for gold and silver). Waste dumps may vary from less than 5 acres for small mines to 500 acres or more for a large open pit mine.

Mill tailings are dispersed as a series of tailings settlement ponds behind dams. As the materials dry they may be subject to dusting in winds. The tailings may contain residues of alkaline flotation reagents or sodium cyanide. Tailings areas may range from a few acres for small vein mines to as much as 2,000 acres for large open pit mines.

Reclamation

At the end of mining the areas are rehabilitated for the major purpose of hazard abatement, restoring productivity and esthetics as may be possible.

Surface facilities can be dismantled and salvaged, over a period of several months to a year. Residual effects may be areas which are graded, compacted or concreted.

For surface mines, hazardous slopes may be reduced (not practicable in

hard rock pits) or fenced at their crest. Larger pits would remain as a residual effect.

Access to subsurface workings would be blocked and sealed over a period of weeks or months. For small mines there may be few residual effects, largely confined to portal areas. For block caved areas, subsidence would be residual effect.

Mine waste and tailings could be graded and shaped to blend more naturally into the surrounding terrain. Some residues can be neutralized and revegetation attempted. Residual effects would be degraded visual aspect and probable reduced vegetative productivity.

Many aspects of rehabilitation can be accomplished during mining: by the mining plan, by planned waste and tailings placement and by commencing rehabilitation on abandoned areas during the life of the mine.

Placer Gold Mining

Operations would be generally small, 5 - 10 acres or less with a few larger operations on low grade deposits such as residual, colluvial or floodplain deposits (as at Glamis), perhaps 30 to 50 acres.

Exploration would involve effects of direct physical sampling (through test pits, cribbed shafts, auger or drill holes) and necessary temporary access. Net areas affected would be quite small, usually less than one or two acres.

Development and mining tend to merge in small placer operations. Mining may commence with bulk sampling and then proceed. The most efficient

separation requires water, a problem in most desert areas. Dry processes have poorer gold recovery and may generate considerable dust. The areas mined might range from a few acres to 10 acres perhaps 20 feet deep, to 30 - 50 acres perhaps 30 feet or more deep.

Placer mining has potential for restoration as mining proceeds. Mined gravels can be replaced, graded and revegetated with possibly little loss in productivity.

I. EXPLORATION
HARDROCK MINING

On-the-ground techniques, sequential activities.	Duration	Area involved	Access needs	Air/Water
Geological (outcrops) Geophysical, Geochemical prospecting of broad areas.	Several weeks to one year.	Broad areas, intensity comparable to recreation use (hiking).	Existing vehicular access.	Negligible
Trenches, pits, exploration headings (adits, shafts) on a narrowed target area.	Several weeks to a few months.	Less than 10 acres. The intensive use areas of working and waste dumps.	Existing access and minor additional developed access for light vehicles.	Minor, intermittent dust.
Together with drilling of a target area.	Several weeks to several months.	A few drill sites within 20 - 1,000 acre target area.	Existing access and development of light to heavy vehicle access.	Minor, intermittent dust. Possible drilling fluid residues.

*Some steps may short cut by

II. DEVELOPMENT
HARDROCK MINING

Techniques, Sequential Activities	Duration	Area Involved	Air/Water
Development drilling	5 to 10 months (overlaps and continues exploration drilling).	Drill sites and their access within 20 to 500 acres.	Minor, intermittent Dust. Possible drill fluid residues.
Surface Mining:			
Removal, Placement of overburden.	Several months to two years.	Several hundred acres.	Dust, intermittent
Initial development of pit working faces (a series of benches).	Several weeks to a year.	Within above area.	Dust, intermittent
or Subsurface:			
Development of underground access preparing to extract, haul, hoist ore and waste.	Less than one year to two years.	Small portal areas.	Minor Dust. Possible water discharge from subsurface workings.
Construction of surface plant (to crush, grind, upgrade ore).	1 to 2 years, (concurrent with above).	5 to 100 acres	Dust
Construction of surface access (roads, railroads, overland conveyors).	A few months to one year (concurrent).	Perhaps 5 - 10 miles, 5 to 6 acres per mile.	Dust
Utilities Development: Water (wells, reservoirs, pipelines). Electricity (transmission	Several months to one year (concurrent).	Together with access roads.	Dust

III. EXTRACTION
HARDROCK MINING

Techniques, Activities	Duration	Area Involved	Air/Water
Surface Mining:			
Open pit, advancing downward on a series of benches. Pit slopes to about 40^{o} - 50^{o}.	5 to 30 years or more.	Up to 500 acres or more, to perhaps 2,000 feet deep.	Dust
Subsurface:			
Vein mining to block caving of large, low-grade deposits.	5 to 30 years or more.	None additional, (see mine waste disposal below).	Possible water discharge.
Milling operations	Mine life	5 - 100 acres, the mill area.	Fluid and gaseous effluents.
Mine waste disposal (may involve heap leaching of low-grade ore).	Mine life	5 - 500 acres	Dust Leaching fluids
Mill tailings disposal.	Mine life	5 - 2,000 acres	Mill fluid residues.

IV. RECLAMATION
HARDROCK MINING

Activities	Duration	Residual Effects
Dismantling, salvage of surface plant.	Several months to one year.	Compacted areas Concreted areas
Reduction, and/or fencing of dangerous pit slopes.	Several months	Some degree of hazard may remain.
Blocking or sealing underground access.	A few weeks to several months.	Few effects at portals. Subsidence at block caved areas.
Neutralization, removal, containment of toxic residues.	Several weeks to months - periodic monitoring.	Reduced vegetative productivity.
Grading, shaping of waste dumps, mill tailings to blend into surrounding terrain.	Several months.	Degraded visual aspect as a permanent effect.
Development of lakes, ponds from pit areas where practicable.	Several months.	Most pit areas would remain as a permanent effect.
Revegetation as practicable.	Short operations within a one to two year period.	Probable reduced productivity.

Gold Mining

Because of the expected continued high price of gold, prospecting efforts are again being seen in all areas where gold may be found. The CDCA has a long history of gold mining and can expect its share of activity.

Large gold mines are possible in the CDCA, both of the open pit and underground variety. Small mines should be much more numerous, however, due to several factors: Large company exploration programs may find ore bodies too small to interest them, but profitable to the small investor; independent prospectors may make new finds, although this should be rare in the well-prospected CDCA; old mines of known history, which were shut down during WW II and never reopened due to low gold prices, may reopen; prospects without production history may be re-examined by government and private exploration programs, and some should prove capable of profitable production.

Small gold-bearing veins are not uncommon in the geologic settings found in the CDCA, and although their values excite amateur gold seekers, the amount of gold is usually very small when compared to the quantity of barren rock which must be mined in order to extract the gold-bearing material on a continuing basis. Also, few amateur miners have the time, money or knowledge needed to properly sample ahead of their mining, and can not anticipate when the gold veins they are attempting to follow may come to an end. Historically, these uncertainties have not discouraged prospectors from wanting to "strike it rich", and so the greatest threat of impact from gold mining may be the "gold fever" urge to rush out to the desert and start digging. In such instances, access roads and poorly planned bulldozing and trenching could severely tax

BLM's ability to monitor these activities and keep them within reasonable and constructive bounds. Areas of the desert which once were blanketed with mining claims may see revived flurries of claim staking.

Underground mining methods generally require little surface disturbance, and some mining methods utilize waste material to fill in the voids created by mining, so that surface waste dumps are small. A typical such mine could occupy less than five acres. An additional 10 acres to 40 acres could be occupied by ore heaps used for leaching methods of gold recovery.

Large operations today use leaching methods for recovery wherever possible, requiring up to several hundred acres for dumps to handle waste rock, and for water recovery systems. Leaching in place (in situ) does not require crushing and grinding the ore; heap leaching on the surface may require crushing but not fine grinding; recovery of low unit values in large operations usually require fine grinding in a mill, with additional steps of dissolving and recovering gold and other associated mineral values.

The common chemical agent for gold recovery is cyanide, a poisonous substance which must be carefully controlled. Cyanide is usually precipitated as a sodium-zinc compound which is recycled or as an iron compound which is disposed of. Iron cyanide is not considered hazardous, but its disposal is carefully controlled by federal and state regulations. H_2S can also be produced during the chemical processes during recovery of dissolved gold from the cyanide solutions. Barren mill waste, similar to very fine sand, can be used as fill in underground mines, or spread in waste dumps. For large operations, waste dumps can occupy over 100 acres.

Surface facilities for small mines are simple and require little land; for large facilities, improved roads, electric power supply, etc., can require substantial land. If large electric earth moving equipment is needed for stripping overburden, up to 35 MW of electric power for each large machine may be required.

Surface facilities for underground mines are usually not affected by the underground workings and can be designed with more flexibility than can surface mines. Open pits and their processing and waste disposal facilities must crowd together to minimize distances for transporting materials of all kinds. Large areas may be needed for waste disposal and ore storage, in close proximity to the extraction area. Surface mining methods generally apply to such ores as iron, disseminated copper and gold, limestone, boron, gypsum, clays and rare earths; underground methods are more often used for all vein deposits and for such commodities as silver, gold, tungsten, lead and zinc.

Uranium

Uranium exploration is typical of most locatable minerals -- selection of a favorable area, field reconnaissance, land acquisition, target definition and evaluation. The last items involve drilling and excavation, and are done after land acquisition because of the significant increase of exploration costs in the later stages. If the land cannot be acquired and access assured, exploration cannot be justified beyond preliminary stages.

Preliminary investigations include study of remote sensing data. Geologic features such as lineaments and alteration zones can be observed from satellite images. Lower level data, including photography and radar can identify smaller features and more subtle differences in color and texture of rock units. Very low level airborne geophysical investigations of gamma ray emission, gravity and magnetism complete the indirect methods leading toward selection of favorable prospecting areas. Ground-based studies of geochemistry, geophysics and geologic mapping may be required for site selection, and overlap into the field reconnaissance stage of exploration.

Field studies may include soil and water sampling, radiometric investigations, studies of electrical and physical characteristics of localities and specific targets, and may include some drilling and downhole logging.

After property acquisition, further site-specific exploration programs, primarily involving drilling, lead to design of mining operations. Surface disturbance due to access by off-road vehicles and trucks during the later stages of exploration would normally be where subsequent mining operations would take place, but could be minimized by careful selection of routes and

drill sites, and by appropriate clean-up after tests are completed.

Uranium ore may be mined by either open pit or underground methods. Where the ore zones extend below the water table, removal of water may change the chemical conditions and result in toxic elements being dissolved in the mine water when it is pumped to the surface for disposal. Extensive treatment of mine waters may be required as a component of proper mine design.

Air quality underground and adjacent to uranium mines may be adversely affected by radon decay products. Dust from haulage trucks or from other handling of radioactive ore may concentrate emissions where the dust accumulates.

Waste rock from uranium mines can release toxic and radioactive materials over time, which can enter into ground water.

Uranium ore is not now being produced in the CDCA. Production would require bringing to the desert facilities for doing at least some of the concentration of ores now only done out-of-state.

In-situ leaching, i.e., dissolving uranium from ore deposits in place, is a technique finding wider application in the uranium industry. There are methods for controlling spread of the chemicals into adjacent soil on ground water. Solutions derived from leaching operations must be stripped of their values at their place of production.

The Nuclear Regulatory Commission licenses uranium production and requires environmental reports with detailed consideration of the kinds of issues touched on here. (Ref: Rouse, J. V., Environmental Considerations of Uranium Mining and Milling, Mining Engineering, October 1978.)

Available are
~~Appendix _____~~ contains examples of currently approved mining plans on Federal lands in the CDCA. These were processed by San Bernardino County through the procedures adopted under the State Surface Mining and Reclamation Act of 1975. BLM and the various counties in the CDCA will consider mining proposals in the future by joint procedures developed under specific memoranda of understanding, designed to bring together the county ordinances and BLM regulations (43 LFR 3809) with as little overlap and duplication as possible. BLM will generally join with the county environmental assessment staffs in making known any special items of federal concern during the county procedures, so that in normal circumstances the procedures will be identified for approval of mining and reclamation plans regardless of land ownership.

Saline Minerals Activity Scenario

This scenario was developed from contacts with several active saline minerals extraction operations presently active on several dry lake beds in the CDCA.

A table has been prepared for this scenario, summarizing the surface disturbance by stages and by cummulative totals. All figures are in acres.

Saline minerals exploration and production on Federal lands are carried out under the authority of the Mineral Leasing Act of February 25, 1920 as amended (41 Statute 437). Surface management control is provided by the National Environmental Policy Act of 1969 (42 USG 4332). Regulations codified under 43 CFR 3500 and various cooperative agreements between the U. S. Geological Survey, the Bureau of Land Management, the Forest Service and the U. S. Fish and Wildlife Service provide for strict surface management controls of a lessee's operations.

A typical saline program begins with the issuance of a prospecting permit which carries a preference right to lease if an economic discovery is made. Exploratory activities concentrate on drilling of the dry lake beds proper, using a track road and a 30x30 foot open site to place the drill truck are required.

If a discovery is made and development proceeds, then a series of wells are drilled into the brine using a 50x50 foot pad which is reclaimed to 25x25 feet after the well is completed. Well spacing is variable, depending on the size of the brine pool encountered, but will average one well per 80 acres.

The brines are conveyed via 10 to 12 inch pipelines to evaporation ponds where the SALT is removed by precipation and the brines are further concentrated. A 20 to 24 inch pipeline will carry the brines from the ponds to the chemical plant for processing. A road net connects the wells to each other and the pipelines follow the roads. All installations except the plant are located on the dry lake bed proper. The salt crust will not support the weight of the plant.

Reclamation is easily accomplished, as the winter rains raise the brines to surface and each winter a new layer of salt is laid down, up to 8 verticle inches per year. This causes all roads and drill pads to be filled in and the dry lake bed is restored to a homogenous surface again. The lessee is faced with re-establishing his roads every year. Once the evaporation ponds are backfilled and smoothed over, all traces of the operation will be removed by natural processes within one year.

Stage	Roads	Drill Pads	Pipe Lines	Ponds	Plant	Stage Total	Cumulative Total
Exploration	4.33	0.2	0.0	0.0	0.0	4.53	4.53
Development/ Production	8.71	10.0	294.00	1100.00	140.00	1631.1	1635.63
Close Down	0.0	0.0	0.0	0.0	0.0	0.0	1635.63
Residual							140.00

Material Sales Activity Scenario

This scenario was developed from a study of the "average" material sales contract which is normally for 10,000 cubic yards of total material for a quarried rock for aggregate purposes.

A table has been prepared for this scenario, summarizing the surface disturbance by stages and by cumultive total. All figures are in acres.

Material sales activities on Federal lands are carried out under the authority of the Materials Act of July 31, 1947 as amended. Surface management control of these activities and reclamation activities are provided by the Act and its subsequent regulations codified under 43 CFR 23 and 43 CFR 3600. The State of California also regulates material sales operations on Federal lands under the State Mining and Reclamation Act (SMRA) of 1975.

Under title 23 USC (Interstate and Defense Highway System), a State Highway Department (ie Caltrans) may apply for exclusive material sales rights of ways on Federal lands for highway construction and maintainance programs. This is handled through the Secretary of Transportation and bypasses the Bureau material sales system. The material sales sites are in the form of exclusive grants to the state and are not subject to the normal BLM proceedures or planning system. This has particular implecations for the Desert Plan, especially class "L".

The major aspects of typical sand and gravel operations are a pit or trench covering 0.74 to 1.0 acres to a depth of approximately 10 feet. The deposits are of predominently sand or gravel and so are located in physiographic areas where erosion and wheathering have reworked sediments into deposits of predominently one particular size. These areas are normally washes, riverbeds, shorelines, and alluvial fans.

The sites are located as close to the use area as possible, because of transportation costs. Typical equipment used are front-end loaders, dump trucks, water trucks, and personal vehicles. The processing equipment is portable, and is moved from site to site, and consists of conveyor belts, sizing screens and occassionally a drying kiln. The equipment is normally set up in the pit itself to minimize handlage costs.

Surface reclamation requires that the pit slopes or trench slopes be left stable and slopes re-contoured at 3:1 to 6:1 (horizontal:vertical). Past experiance has shown that vegetation and wildlife return to the reclaimed site within two years after activity ceases.

A rock quarry operation will entail hard rock mining by a small open pit, using explosives to break the rock. Quarry size is 1-2 acres in area and verticle extent is variable, depending on topography. Cliff faces or ledges are preferred due to easier access to the rock and greater ease of rock removal. Equipment used and operational methods are the same as in the sand and gravel type of operation.

Site reclamation entails clean-up of the site, stablization of the walls and slopes, and recontouring the area so as to leaveit a form suitable for other multiple uses.

Wildlife and vegetation return within two to three years after the operation ceases.

STAGE	ROADS	PIT/QUARRY	CUMULATIVE ACREAGE USED
Exploration	0.50	NONE	0.50
Development/ Production	0.25	1.5	2.25
Reclamation	0.0	0.0	2.75

Roger Haskins.

Geothermal Activity Scenario

This scenario was developed from the offical documentation of the history of Magma Electric company's 10MWe geothermal power plant on the East Mesa of Imperial County, California. It is the only completely documented geothermal power system on the California Desert (the only power plant at present) and it is currently in operation.

A table has been prepared for this scenario, summarizing the surface disturbance by stages and by cumulative total. All figures are in acres. An outline of geothermal activities from initial exploration to production to closedown is included.

Geothermal operations on Federal lands are carried out under the authority of the Geothermal Steam Act of December 24, 1970 (PL 91-581) Strict surface management control of all geothermal activities are provided by the Act and its subsequent regulations codified under 30 CFR 270 and 271, 43 CFR 3200, and the Geothermal Resource Operations Orders (GRO's) issued by the U.S. Geological Survey and all lessees and operators must comply with its provisions or face punitive action, up to and including lease termination in the most severe cases of noncompliance. GRO #4 is solely concerned with the environmental controls and safeguards on Federal geothermal leases and the reader is advised to read GRO #4 before appling this scenario, so as to better understand the modern surface management controls that exist on geothermal operations.

Magma Electric present 10 MWe power plant and its initial developement was carried out under the above referenced regulation and represents a model of maximizing geothermal resource development while minimizing environmental impacts related to surface disturbance.

The major aspects of the operation are designing the road and drill pad net to be reused for development if the initial exploratory drilling were successful. The five production wells were all drilled from 2 pads of 1.61 acres each, 3 wells from one pad, two wells from the other. The injection wells (3 of them) were likewise all drilled from one 1.61 acre pad, thus minimizing drill pad proliferation and surface disturbance.

Pipelines and power lines were placed along the shoulders of the roads, and the pipelines are elevated on concrete pedastals to be a minimum of one foot of the ground to allow for wildlife mobility and thermal expansion. All pipelines are insulated with two inches of fiberglass insulation to prevent heat loss and possible safely hazards.

All power lines are constructed to be raptor compatible so as to prevent electrocution of raptors and other large birds.

The power plant operates on a closed cycle system and does not emit any gases to the outside atmosphere, as all production fluids are re-injected into the resevoir. The cooling ponds contain fresh water obtained from the nearby East Highline Canal and spent cooling water is discharged into the nearby Warren Drain.

All noise levels are mandated to be no greater than 65 dBA at a distance of 1500 feet from their source or the lease boundry, whichever is the closer.

The power plant was operating during the 6.4 magnitude earthquake of October 15, 1979 and suffered no noticable damage or impairment to any of its facilities, despite being only 5 miles from the earthquake's epicenter.

All wildlife and botanical mitigation for the operation was approved by the Bureau of Land Management, U.S. Fish and Wildlife Service, and California Department of Fish and Game. The cultural resources mitigation was approved by the State Historic Preservation Offices. As the area contains sensitive wildlife and botanical species, as well as numerous cultural resources sites, its acceptance of BLM and ~~USGS~~ mitigation efforts is to be noted.

APPENDIX A

I. GEOTHERMAL RESOURCE DEVELOPMENT STAGES

The discussion which follows is a generalization of the stages and activities which may occur during the search for and development of geothermal resources for both the electrical and non-electrical models. The activities described are representative of a typical exploration and development program; variations can occur and, depending on the success of each preceeding activity, all or only some of the activities may be conducted. The discussion is modified from Raschen and Cook (1976).

A. INITIAL EXPLORATION STAGE

Initial exploration studies include activities that are not surface-oriented and result in no impact on the region. These activities include a literature review, broad geologic studies, aerial photography or imagery, and airborne magnetic surveys. These may be carried out on non-leased lands or on leased lands.

B. PRELIMINARY EXPLORATION STAGE

These are carried out under 43 CFR 3209 and can be done by a lessee or non-lessee on leased or non-leased Federal lands. The permitting is a BLM discretionary action.

1. Geological Mapping.

a. A mapping program will provide for an understanding of the local geology. While most of the data is gathered on foot, this activity may involve some off-road vehicle (ORV) use. Rock, soil, or spring (water) samples may be collected.

2. Geochemical Studies.

a. Water Sampling.

An analysis of water samples may yield information about geothermal temperatures and fluids. Samples are usually collected in small bottles and access may be on foot or with ORV's.

b. Soil/Rock Analysis.

Here activities are essentially identical to those described above for geological mapping. Information regarding geochemical make-up is usually sought and age dating analyses may also be performed.

C. GEOPHYSICAL SURVEYS

1. Gravity Surveys.

These surveys are conducted to obtain information about subsurface temperatures and geological structures. Instruments are portable and hand-carried. The survey includes a vehicle for transportation and a three-person crew. Existing roads are used and cross-country movement by foot also occurs.

2. Magnetic Surveys.

To aid in the delineation of subsurface rock bodies, magnetic surveys may be conducted. Activities are identical to those associated with gravity surveys and one or two small vehicles may be employed.

3. Resistivity Surveys.

These activities involve two or three small trucks and three to five people. Only existing roads need to be used if available and two widely separated electrodes, two miles (3.2 kilometers) apart approximately two to three feet (1 meter) long, are driven into the ground to deliver the electrical current. Small receivers at the surface record currents. These surveys can reveal subsurface geological structures.

4. Magnetotelluric Surveys.

These surveys are designed to measure natural electrical currents in the earth's crust. Activities are similar to those associated with resistivity except that smaller crews and fewer vehicles are needed.

5. Radiometric Surveys.

Natural radioactive emissions, such as radon gas, are monitored during these surveys. Hand-held equipment is used and existing roads are utilized whenever available.

6. Passive Seismic Studies.

These activities generally involve the burial of small geophones (seismometers) for micro-earthquake or "ground noise" measurements. Recorded signals from distant sources may be analyzed to deduce subsurface rock properties in the survey area. Existing roads may be utilized and trail bikes may be used for off-road travel. A two or three-person crew is required.

7. Active Seismic Studies.

These studies are designed to provide information about a substratum's composition and structure. Activities involve the generation of artificial elastic shock waves through one or more of three methods: (1) vibration method whereby as many as four or five truck-mounted vibrators operate in unison; (2) thumping method whereby heavy weights are dropped from trucks to produce vibrations, (the trucks may remain stationary or move from station to station, and weights may range from 300 pounds (135 kilograms) mounted on a 3/4-ton pickup to very heavy units mounted on three-ton trucks); (3) explosive method whereby a small truck-mounted rotary drill is used to drill shallow (up to several hundred feet (meters), small-diameter, generally three to five inch (8 to 13 centimeter) holes spaced up to 1/2 mile (.8 kilometers) apart. Water and a gel are generally used for circulation as are portable metal mud pans; however, cuttings can also be removed with compressed air. The drilled hole is then loaded with several pounds of explosives, filled with water, and the explosives detonated. Geophones are arranged around the shot hole to detect the resulting shock waves.

In each of the methods, from five to seven trucks and 15 people may be needed and temporary access roads may need to be developed.

8. Shallow Temperature Holes.

These holes are utilized to measure thermal gradients. The holes are generally no more than 500 feet (150 meters) deep and the methods described above for shot holes are generally employed for shallow temperature holes. Initially spaced at two to five miles (3 to 8 kilometers) apart, the spacing is reduced as exploration continues. Upon completion a small (about one inch) tube is placed in the hole, the holes are filled with water, capped, allowed to remain undisturbed for about a week, and then the water temperature is probed with a temperature device. Temporary access roads are needed and a clearing about 30 feet by 30 feet (10 meters by 10 meters) is needed for the drill site.

9. Observation Holes.

In order to obtain additional information on subsurface geology, observation holes may be drilled. These holes are generally larger and deeper than those previously discussed. They may range up to 2,500 feet (750 meters) or deeper and be 6 1/4 to 7 1/2 inches (15 1/2 to 19 centimeters) in diameter. Drilling mud will probably be the circulating medium and a mud pit three feet to six feet (1 to 2 meters) deep will be constructed with a bulldozer. In all, a surface area of 40 by 60 feet (12 by 18 meters) may be utilized for the drill site. The entire operation may require three crews of three people each and intermittent vehicular traffic on either existing roads or temporary access roads. The drilling is usually completed within two weeks.

Upon successful completion of a preliminary exploration program, the decision will probably be made to further explore and develop the potential field, with the air of eventually developing the commercial geothermal resource.

D. EXPLORATION DRILLING STAGE

1. Road Construction.

In contrast with the temporary roads required for some of the earlier phases of exploration, roads at this stage are of much better quality. They are designed to carry heavier loads, withstand a much more constant traffic burden, and function year-round if necessary. Steps to achieve these qualities include surfacing with rock, gravel or volcanic cinders, or mixing oil with about the first four inches of soil. In hilly terrain, cut and fill construction may be required and a means for surface water runoff will need to be provided. This can be done by constructing drainage culverts parallel to the road bed and providing drainage conduits where any road-fill crosses drainage areas.

2. Drill Pad Construction.

A drill pad is an area which is leveled and cleared of vegetation. The pad must be large enough to accommodate the drilling rig and accessories, temporary structures, and crew parking. Some maneuvering room must also be allowed for service and delivery vehicles. The required surface, including the drill sump, varies from less than one to two and 1/2 acres (.4 to 1 hectare). In hilly regions, pad construction will very likely entail cut and fill techniques. It is sometimes necessary to surface the pad with rock or gravel where vehicle or foot traffic is heavy.

3. Sump Construction.

A reserve pit, called a "sump", is required for the containment of waste fluids and drill cuttings. Since the size of the sump depends on the anticipated depth of the hole, the surface can range from less than a hundred to several thousand square feet (several hundred square meters) and the depth from five to ten feet (1.5 to 3 meters) or more, depending on required volume. Since the sump is designed to contain fluids, special precautions are required to insure impermeability. The bottom and sides of the sump are lined with an impervious material. The sump is positioned approximately 35 feet (11 meters) from the hole location of the pad so that when the drilling rig is brought in, the sump will be favorably located adjacent to the rig. In a developing field, the same sump may be used for drilling several development wells.

After the road, drilling pad, and sump are completed, a 26-to 36-inch (65 to 90 centimeter) hole is drilled with an auger to a depth of 50 to

100 feet (15 to 30 meters) and a 20 to 30-inch (45 to 75 centimeters) conductor pipe is inserted and cemented to the surface.

E. DRILLING PROCEDURES

1. Typical Equipment.

The largest piece of equipment is the drill rig itself, which may stand over 100 feet (30 meters) high and is composed of a variety of accessories, generally assembled together on the location. These accessories may include (1) mud tanks measuring roughly 40x8x6 feet (12x2x2 meters) for mixing and/or storing drilling mud; (2) blow-out prevention equipment; (3) air compressors for drilling with air; (4) a pipe rack for storing pipe, generally thousands of feet in 30-foot (9 meter) segments; (5) mud pumps; (6) engines of up to 1,000 horsepower; (7) a cooling tower up to 30 feet (9 meters) tall for cooling drilling mud during the later stages of drilling; (8) fuel tanks; and (9) water tanks. In addition, office and storage buildings and/or trailers need to be located in the immediate vicinity.

2. Personnel.

Both "permanent" or rig and "temporary" or service personnel are associated with a drilling rig. Rig personnel include the four to five-person crews: geologists, supervisors, contractor, etc. Service personnel include delivery and specialized service personnel. The total number of rig personnel ranges from 17 to 22 and service personnel from 10 to 15, with a total of 27 to 37 people associated with the rig. The maximum number expected on the site at any one time, however, should be no more than five to ten.

3. Drilling Process.

Depending on several variables, the drilling process may range from 12 days to 50 days or more. The rotary method is utilized most commonly and may utilize mud or air as the circulating medium.

a. Drilling With Mud.

During this process, a drilling mud is pumped down through the drill pipe, exits through jets in the drill bit, and travels up the space between the drill pipe and the hole. The mud is directed to the sump pits and from there it is pumped for recirculation, back into the hole.

Drilling mud serves several purposes during the drilling process, such as: a) Transporting drill cuttings to the surface; b) Controlling rock

formation pressures; c) Maintaining borehole stability; d) Protecting productive formations; e) Protecting against corrosion; f) Cooling and lubricating the bit and drill string.

The mud itself is more typically a water-base solution containing basically inert additives such as water, bentonite (clay), lignite, lignosulfate, sodium hydroxide, and barite (Simpson, 1975).

About 500 to 1,000 barrels (1 barrel = 42 gallons = 160 liters) of water per day will be used in drilling a well with water.

b. Drilling With Air.

During the process, the drilling occurs as outlined above. Air is now the circulating medium instead of fluids. Because particulate matter is being "blown" out of the hole, equipment is installed to divert the dust, steam, and air to the sump. A silty material may settle onto the area immediately surrounding the drill site.

Noise levels during the activities may range quite high, approximately 125 dB (decibels). This phase lasts generally from one to three weeks.

4. Casing Program.

During this program, steel casing of varying diameters will be cemented into the hole.

5. Directional Hole.

This process involves generally similar activities and equipment as described in the above vertical drilling processes. Costs are higher and more time is required to complete the drilling because the hole is not drilled vertically.

6. Blowout Prevention.

A blowout occurs when subsurface formation pressures exceed pressures produced by the column of fluid or in the bore hole. Various types of blowout controls can be installed on the casing to prevent such an occurrence. Generally, the equipment consists of one or more of the following items:

a. Equipment

(1.) Expansion type preventer - essentially a larger rubber doughnut which may be compressed to close an object of any size or shape in

the hole, or a rotating head which contains a packing element which rotates with the drill pipe.

(2.) Pipe rams: so called because they have an opening of a size to close around the drill pipe.

(3.) Blind, blank or complete shut-off rams: rams which close completely, shearing anything in the hole.

This type of equipment is installed at the surface on top of the casing.

7. Testing The Wells.

When drilling is completed, the well is allowed to flow to the surface. Flow is directed to the drilling sump, through a series of mufflers, or under water to further reduce noise. This flow is composed of both fluids and noncondensable gases. The various fluids from Imperial Valley wells may contain more than 30% (by weight) of dissolved solids and include significant concentrations of several toxic elements (Werner and Olsen, 1970, Lawrence Livermore Laboratory, 1975a).

The noncondensible gases and vapors make up a small percent of the gaseous volume, generally less than three percent. Minor or trace amounts of other compounds or elements have also been reported (Axtmann, 1975, Lawrence Livermore Laboratory, 1976a). If testing releases substances that are detrimental to the environment, these toxic fluids and gases will be removed and contained in the sump or in portable tanks.

It is difficult to determine the quantities of fluids that may need to be disposed of. If electrical generation is assumed, the number of wells servicing a power plant would be dependent on the temperature of the wells and the reservoir characteristics and it is not improbable to assume that 15 to 20 wells would be needed for a 55 MW plant, with a spacing of one well per 20 to 40 acres (8 to 16 hectares).

Table A-1 lists the amounts of geothermal fluids that may be produced during tests of 20 wells for a 3-day period.

TABLE A-1
QUANTITIES OF FLUIDS EXPECTED DURING TEST OF
GEOTHERMAL EXPLORATION WELLS - 3 DAY TEST ASSUMED *

Fluid Production per Test Well	2,010,000 gallons (7,638,000 liters)
Amount Converted to Steam	402,000 gallons (1,527,600 liters)
Amount Left For Disposal	1,608,000 gallons (6,110,400 liters)

*Data modified from U.S. Department of the Interior, 1975.

The amount of fluids for disposal will be increased for the non-electrical models because the non-electric applications utilize the liquid form of water with its lower calorific value whereas electrical production uses high temperature steam. (Lawrence Livermore Laboratory, 1975b).

At the present time, it is not possible to accurately estimate how much fluid will need to be disposed of if non-electrical applications are realized.

8. Well Abandonment.

Depending on the depth and purpose of the hole, various schemes of abandoning the hole are utilized. These schemes involve various quantities of drilling mud, cement, cement plugs, and casing. All equipment, structures, and refuse are removed and the site is graded.

F. FIELD DEVELOPMENT STAGE

1. Plant Construction.

The first phase in plant construction is the selection of a site. The site selected is more or less fixed by the locations of the geothermal wells. Legal boundaries and available surface and engineering hazards such as slope stability also affect the site selected.

The typical plant site occupies from two to five acres (1 to 2 hectares). In very rare cases, up to 10 acres (4 hectares) may be utilized, including parking facilities, tool storage buildings, etc.

A power plant will consist essentially of a turbine generator, steam condenser and cooling towers. If noxious gases are present that exceed air quality standards, additional equipment for removal is necessary.

2. Pipeline Construction.

After the plant is constructed, pipe lines are run from each well to the plant and then from the plant to an injection well, creating a surface network of pipes. Because the pipes must be able to expand and contract, they cannot be economically laid underground. Pipes about 20 inches (45 centimeters) in diameter are connected at intervals with expansion loops. The size of the network will depend on the number of wells required to power the steam turbine. A typical well will have a productive capability of three to five MW.

These pipes will carry geothermal fluid at a temperature above 200-400^{o}F (165^{o}C) and pressures of not more than 200 pounds per square inch (psi).

3. Transmission Line Construction.

It is necessary to construct transmission lines and towers to transport electrical power generated. The towers occupy a surface area of probably not more than 400 square feet (36 square meters) each on 90 foot (27 meter) rights-of-way.

G. PRODUCTION AND OPERATION STAGE

By this phase of the operation, all facilities have been erected and no additional impacts are entailed directly from construction activities. Some noise, noxious gases, and toxic elements in the geothermal waters will continue, although somewhat abated. The rate of production of each of these will be less than during the testing phase. During the production and operation stage, activities primarily will consist of the operation and maintenance of the power plant and existing wells, the drilling of new wells, waste disposal, and water utilization. Electrical energy generation may be expected to continue for many years.

Exploration and development are typically carried on in other parts of the geothermal field simultaneously with the operational and production activities.

Repair, maintenance, and monitoring of an operating field will require the periodic use of access roads to service the equipment. Existing wells will require occasional repair work or cleanout. The amount of this remedial work will depend upon the production characteristics of the field. Severe scaling and corrosion of equipment from chemicals encountered during development would require frequent maintenance.

Normally, one medium-sized drill rig would be required to drill new wells to maintain generating capacity.

Production slowly diminishes heat flow, therefore, additional wells must be completed to keep the plant operating at full capacity.

If the waste waters are disposed of by injection, new injection wells may be drilled. The technique and effects of drilling these wells would be the same as for development wells.

Cooling towers consume about 40 to 45 acre-feet (approximately 5 hectare-meter) of water per year for each megawatt of plant capacity (U.S. Department of the Interior, 1975). A 55 MW plant would thus consume about 2,500 acre-feet (300 hectare-meter) of water per year. The water may come either from steam condensate, waste geothermal water, or from any other available source.

It is during this stage that disposal of spent fluids become most significant, simply because of the volume requiring disposal. Disposal techniques vary, depending on the quality and quantities of effluent involved.

It is most probable that two of the various disposal methods available may be allowed in the Imperial Valley. These two techniques are:

1. By-Product Development.

   In some instances it may be economical to extract useful minerals or gases from the geothermal fluids. This could result in improving the waste-water quality so as to make it available for other purposes. Desalinization may also be feasible in some areas, providing by-product fresh water for other uses. These uses are permitted under the Geothermal Steam Act of 1970, providing that the by-product value does not exceed 75 percent of the value of the steam.

2. Reinjection.

   With this technique, excess water is reinjected into nonproductive zones of the geothermal field. Successful reinjection is dependent on the quality of the waste water and the geologic characteristics of the geothermal field. Typical considerations would include: whether plugging and scaling problems would prevent the reservoir from accepting the fluid; whether fresh-water aquifers can be adequately protected from contamination by hot saline waste water; and whether the sub-surface rock structure would adequately hold the reinjected fluids.

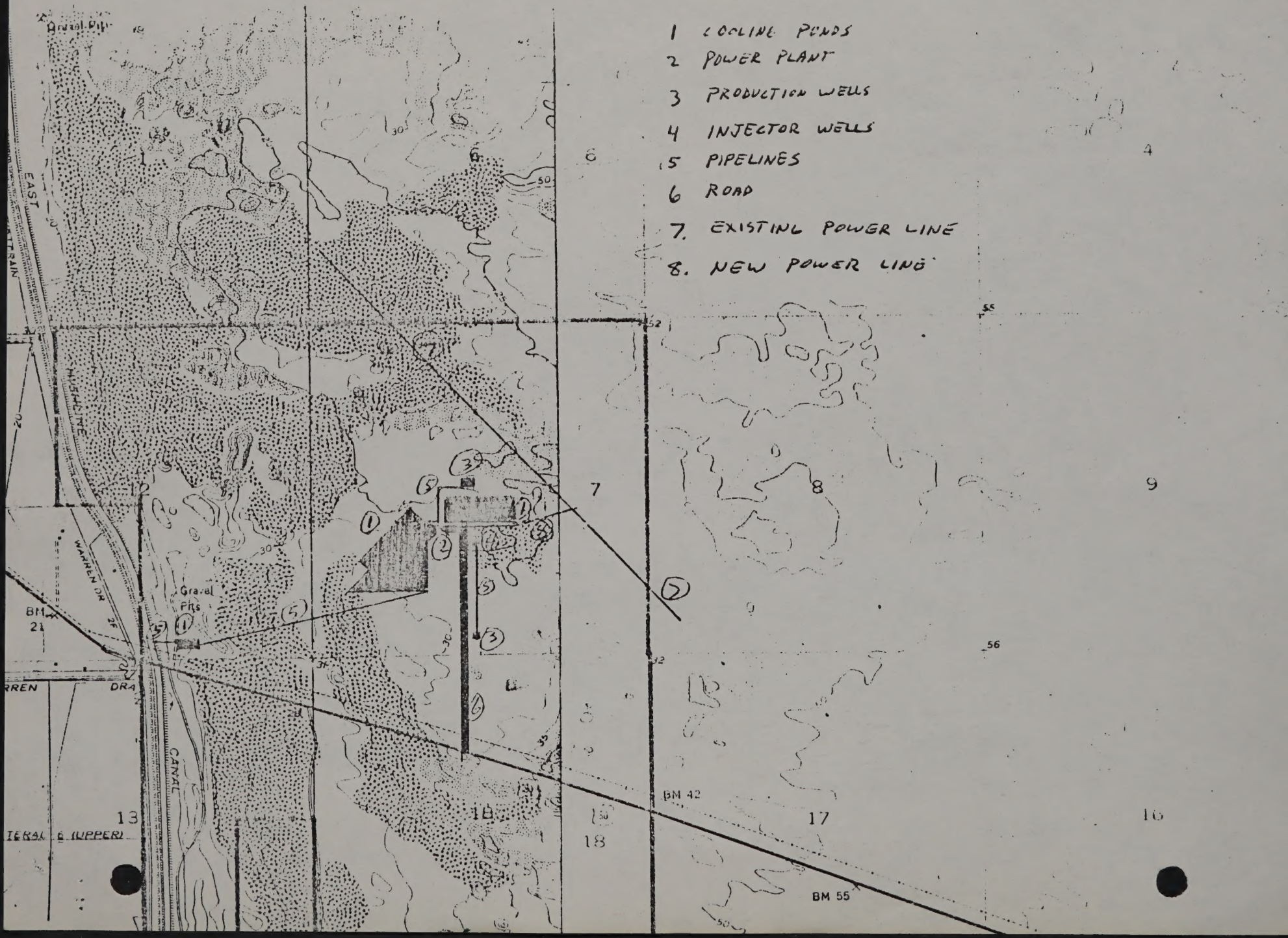
H. CLOSEDOWN STAGE

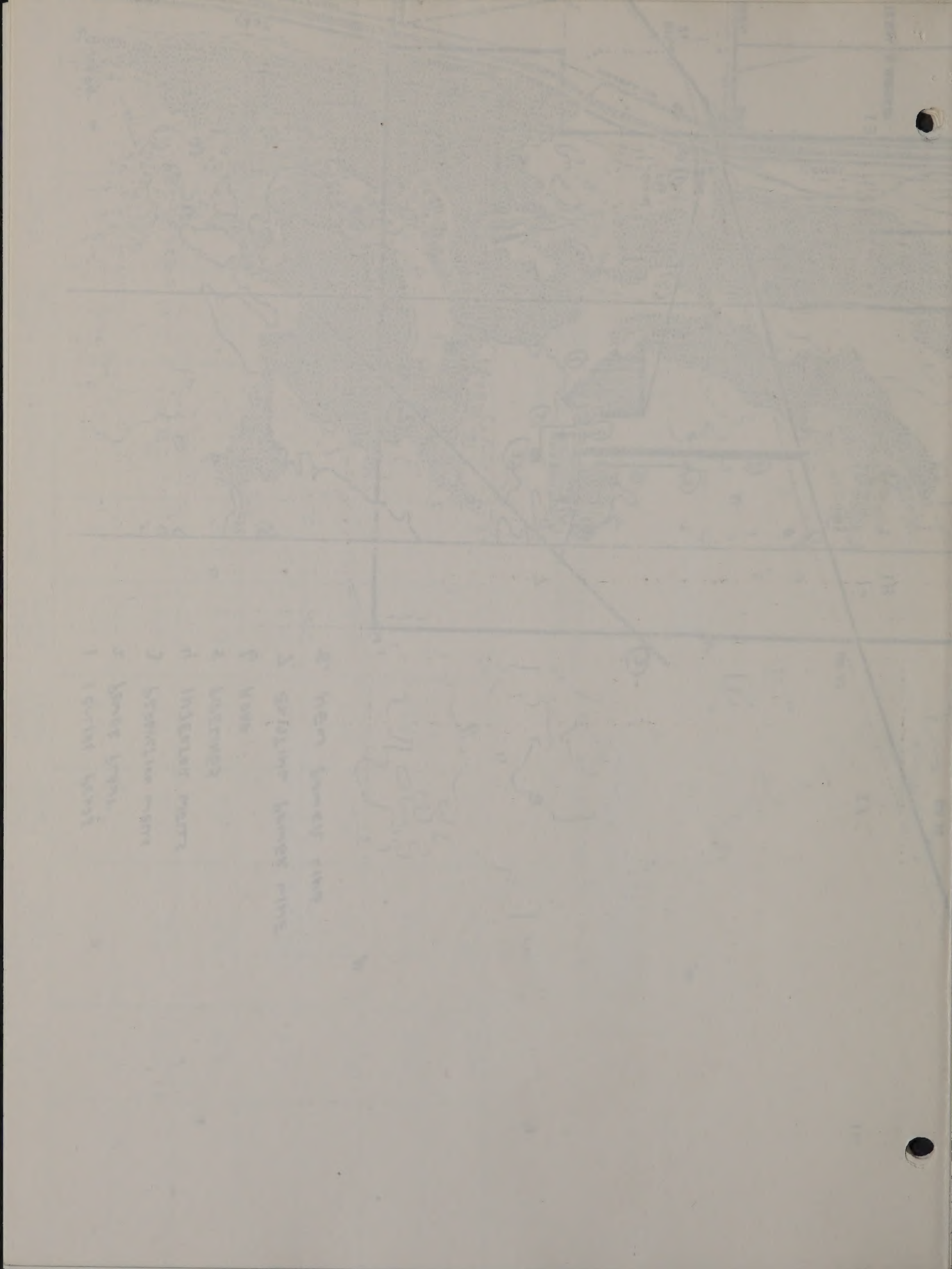
This stage consists essentially of site abandonment and would occur when the geothermal resource is depleted. Geothermal steam reservoir knowledge has not advanced to a stage where a reasonable economic limit can be predicted, but for planning purposes, 30 to 50 years is assumed, which is merely the steam plant amortization period.

The close-out stage includes the removal of all surface facilities, abandonment and capping of wells, and surface rehabilitation.

Stage	Roads	Pads Drill	Pipelines	Ponds	Power Plant	Power Lines	Stage Total	Cumulative Total	% of Lease
Initial Exploration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Preliminary Exploration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geophysical Surveys	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exploration Drilling	2.05	3.45	0.0	(1) 0.62	0.0	0.0	5.50	0.0	0.29
Field Developement	0.33	(2) (1.38) 4.83	2.05	(3) 37.19	0.92	0.92	42.79	48.29	2.29
Production and Operation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.29	2.29
Close Down and Reclamation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.29	2.29

1. Included in Pad Area
2. 1.38 is the actual additional disturbance
3. Does not contain the 0.62 A of temporary drill sumps on the pads.


1 COOLING PONDS
2 POWER PLANT
3 PRODUCTION WELLS
4 INJECTOR WELLS
5 PIPELINES
6 ROAD
7. EXISTING POWER LINE
8. NEW POWER LINE
EAST
HUSHPUPPY
WARREN DR
Gravel Pits
BM 21
CANAL
BM 42
BM 55
13
18
17
16
7
8
9
4
6



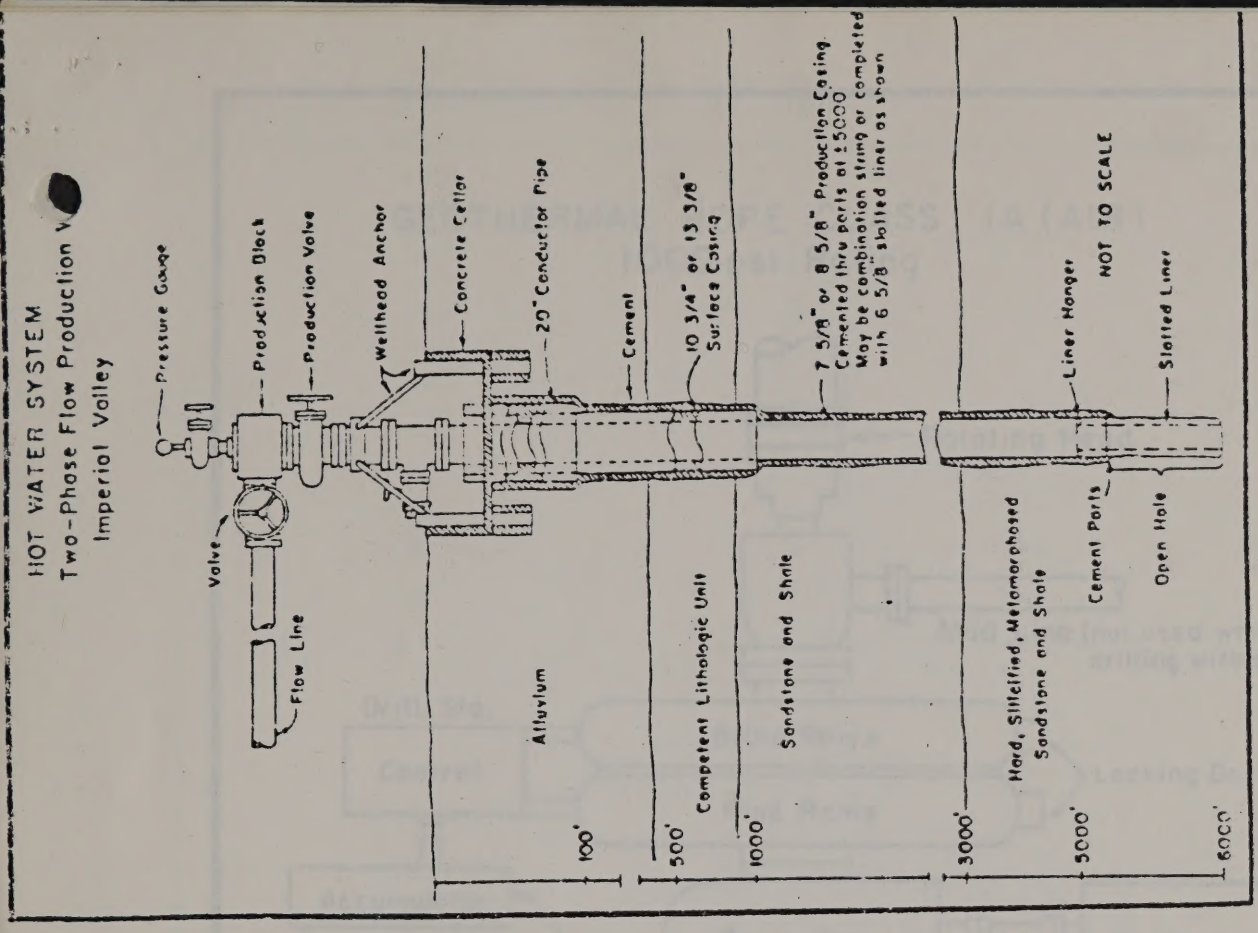


FIGURE 8 DIAGRAM FOR A TYPICAL CASING SCHEME FOR A PRODUCING WELL IN A TWO-PHASE (WET-STEAM) RESERVOIR (CAMPBELL, 1974, FIGURE 3)

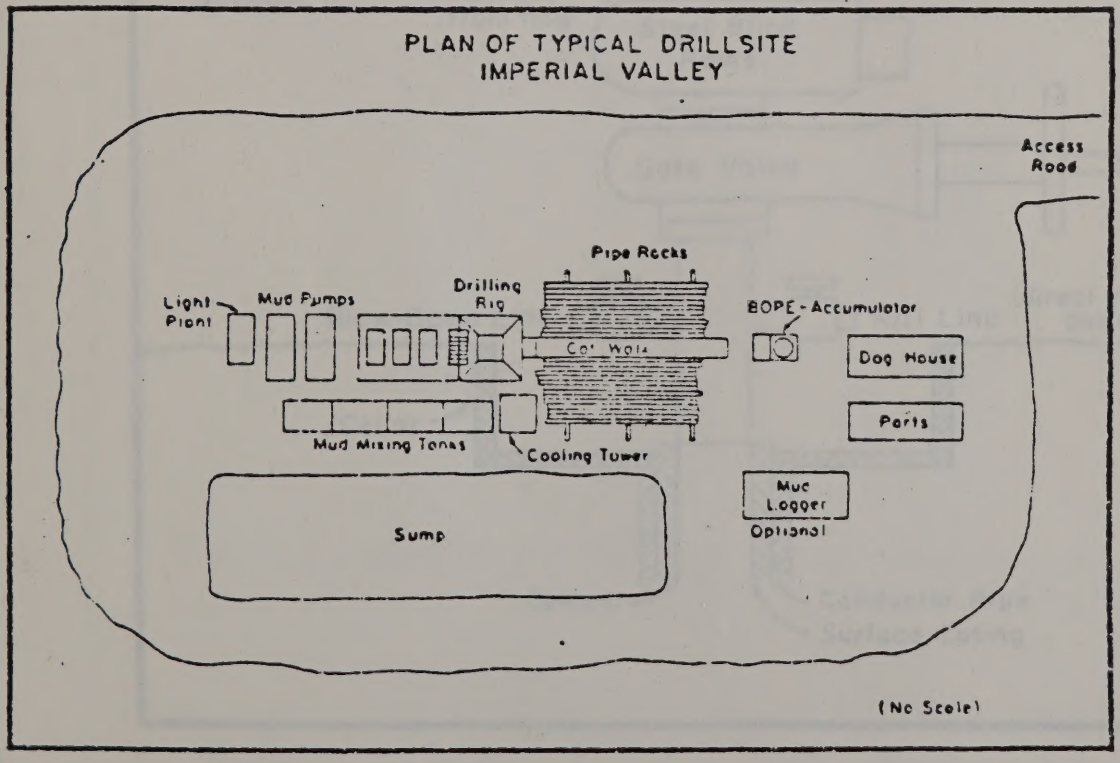
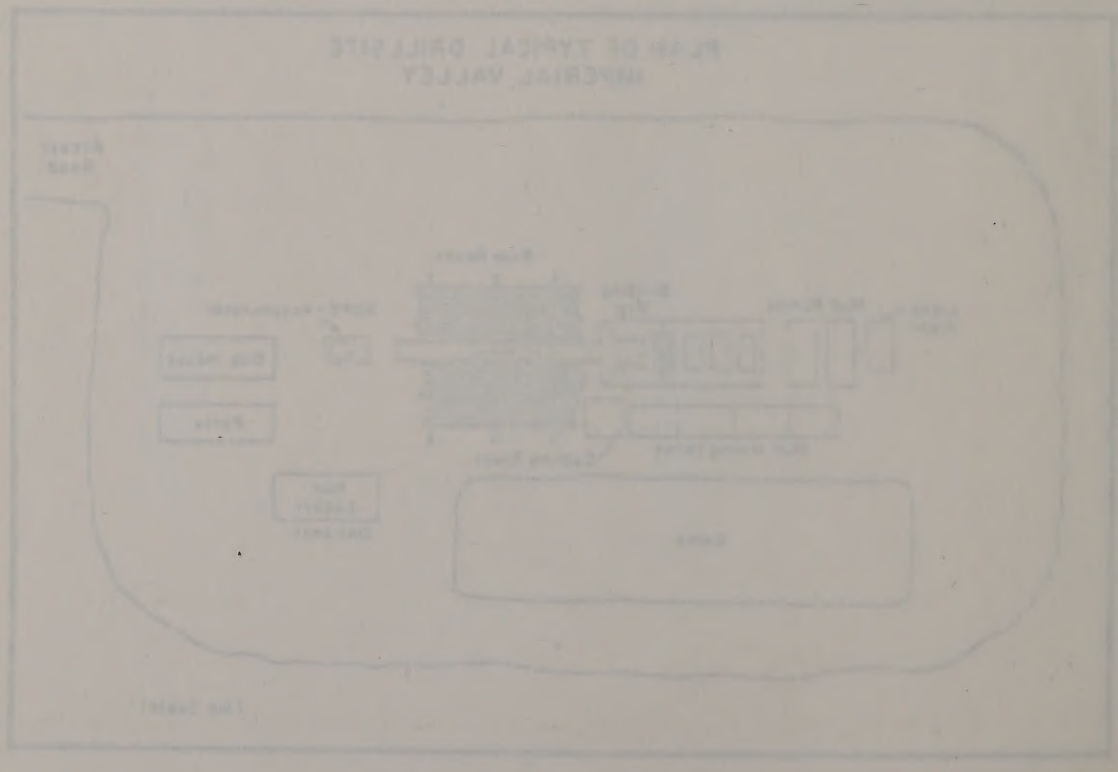


FIGURE 6 PLAN OF TYPICAL DRILLSITE, IMPERIAL VALLEY
(CAMPBELL, 1974, FIGURE 4)



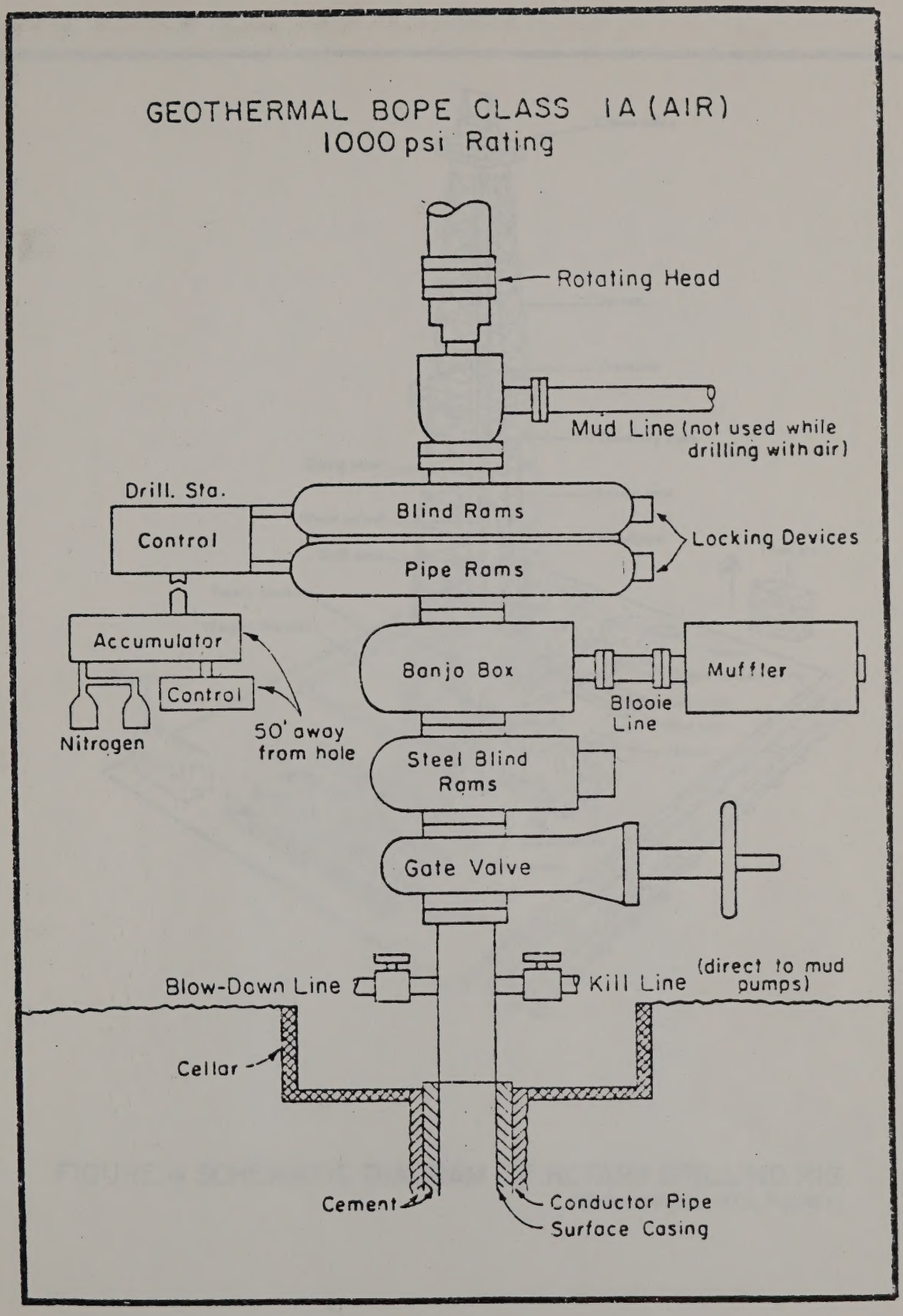
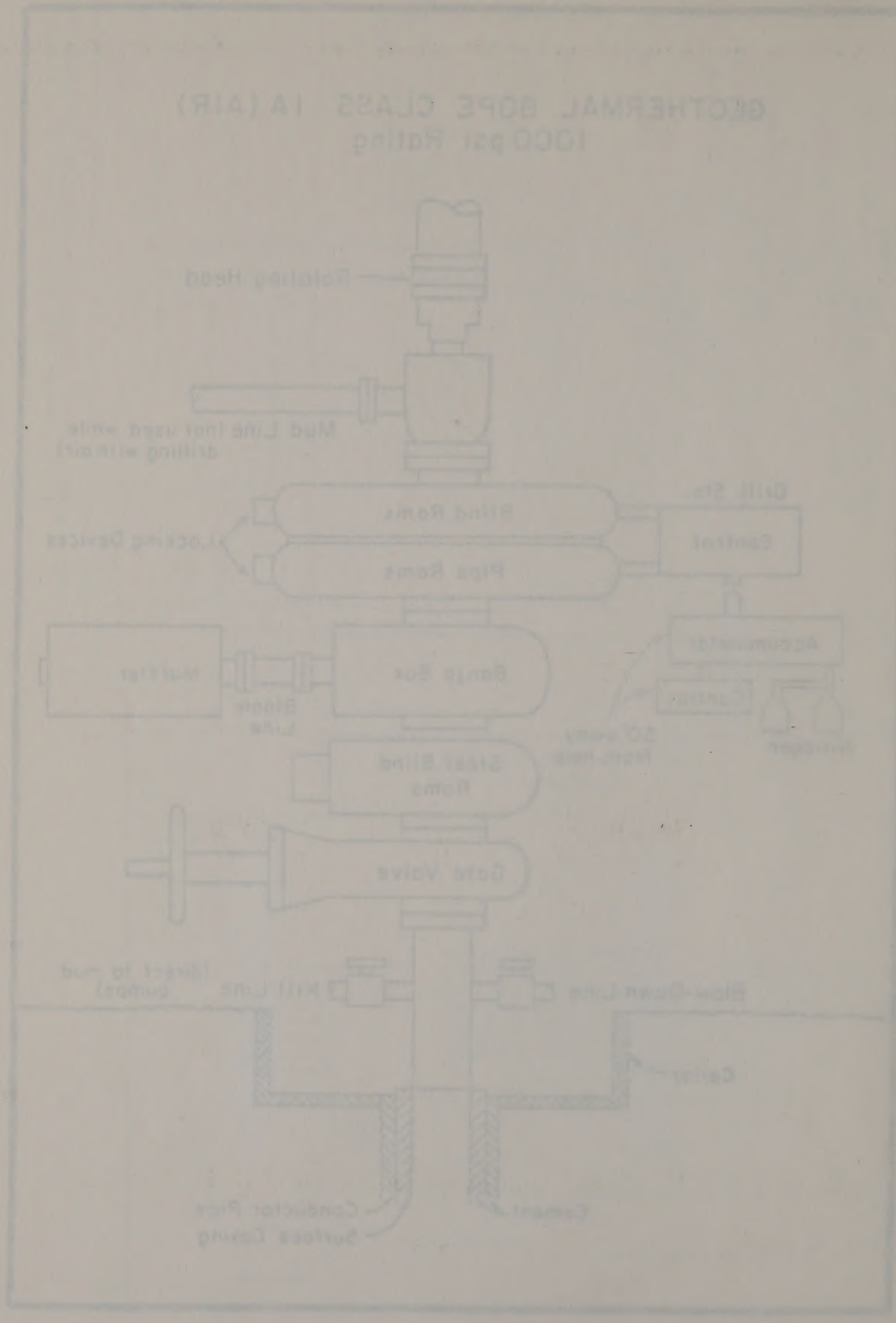


FIGURE 9 DIAGRAM OF TYPICAL BLOWOUT-PREVENTION EQUIPMENT USED IN AIR DRILLING (CAMPBELL, 1974, FIGURE 6)



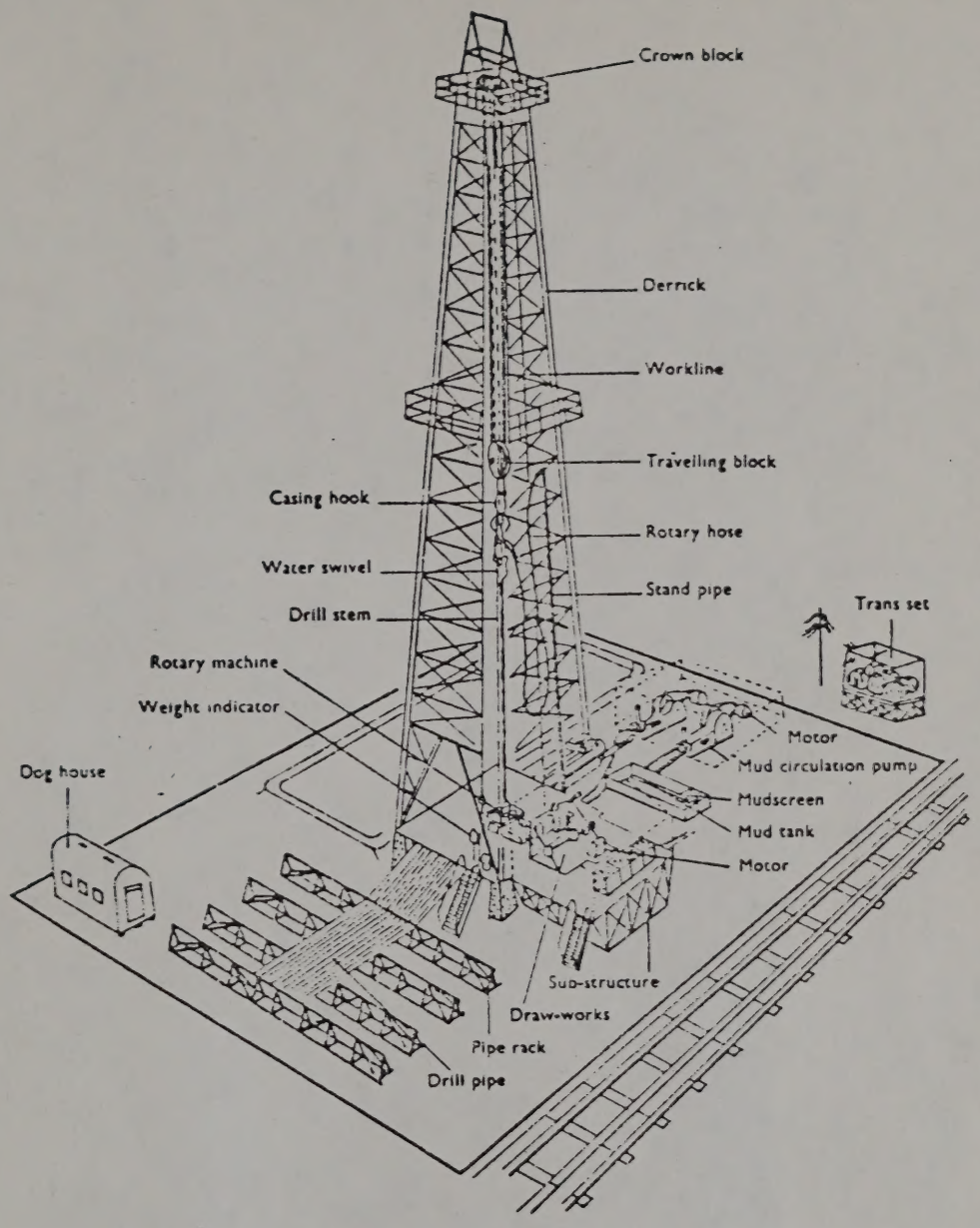


FIGURE 4 SCHEMATIC DIAGRAM OF ROTARY DRILLING RIG
(FROM: MATSUO, 1973, FIGURE 1)